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(54) **Anti-dnase-gamma antibody, and production and use thereof**

(57) Polyclonal antibodies and monoclonal antibodies specific for DNasey, hybridomas producing anti-DNasey monoclonal antibodies and an immunological detection method and purification method for DNasey using the antibodies are provided. By using a peptide containing the C-terminal portion sequence of the DNasey molecule as an immunogen it is possible to obtain anti-DNasey antibodies that specifically recognize DNasey. The DNasey monoclonal antibodies and polyclonal antibodies of the invention are characterized by specifically recognizing DNasey proteins.

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## Description

## BACKGROUND OF INVENTION

## 5 1. Field of Invention

[0001] The present invention relates to specific polyclonal and monoclonal antibodies against the enzyme DNasey that is implicated in apoptosis, to hybridomas that produce the monoclonal antibodies and to an immunological detection method and purification method for DNasey using the antibodies.

10

## 2. Related Art

[0002] In recent years, apoptosis has been a major focus in the study of cell death. Unlike necrosis, which is passive cell death occurring suddenly due to burn or bruising, apoptosis is considered to be physiological and pathological cell death which is preprogrammed into the genes of the cell itself. That is, it is believed to be active cell death that occurs when triggering by some external or internal factor causes the gene programmed for apoptosis to be activated and the autodestruct program to be initiated.

[0003] Apoptosis is associated with a great many biological phenomena. Specifically, apoptosis has been implicated not only in morphogenesis during the development process but also in the case of mature individuals, in alternation of normal cells (removal of aged cells) such as epidermal cells of the skin and epithelial cells of the small intestine and stomach, atrophy due to glucocorticoids in the thymus which is a hormone-dependent tissue, atrophy of the prostate due to castration, as well as elimination of immunocompetent cells that react with self components or nerve cell death due to removal of neurotrophic factors.

[0004] Apoptosis is seen not only in such physiological cell death but also in pathological cell death of cells exposed to radiation or virus-infected cells. Cell death by apoptosis has also been reported as a cause of the reduction in T cells due to the AIDS virus, and is receiving attention for this reason. Apoptosis also occurs by chemical and physical stimuli such as administration of drugs or toxins, and heat. Apoptosis has also been clearly associated with nerve cell death in such neurodegenerative diseases as Alzheimer's, in natural elimination of tumor cells at cancer lesions and in cell death provoked by anticancer agents.

[0005] Consequently, elucidation of the molecular mechanism of apoptosis is important for gaining an understanding of the biological significance and physiological role played by cell death in the fundamental processes of life, including individual development, adult health maintenance and control (regulation) of oncogenesis.

[0006] The characteristic phenomena common to apoptosis are morphological changes such as cell contraction accompanying cell membrane alterations (loss of microvilli) and chromatin condensation, and fragmentation of chromatin DNA [Br. J. Cancer 26, 239-257(1972); Nature 284, 555-556(1980)]. Fragmentation of chromatin DNA into nucleosome units is the most notable phenomenon seen in all apoptotic cells regardless of the diversity of the factors responsible for its occurrence, and this suggests that the apoptosis cascade converges on the process of fragmentation of chromatin DNA.

[0007] The present inventors have discovered, isolated and purified a novel endonuclease DNasey that causes the DNA fragmentation characteristic of apoptosis. As a result of continuing research, it has been confirmed that DNasey is an endonuclease involved in the fragmentation of chromatin DNA during apoptosis, and the inventors have successfully determined and obtained the primary structure of the DNasey and the nucleotide sequence of its gene (Japanese Unexamined Patent Publication HEI No. 8-187079).

[0008] Since DNasey causes DNA fragmentation in apoptosis, elucidation of DNasey and its regulating mechanism is highly important in gaining an understanding of the overall molecular mechanism of apoptosis and the mechanism of cell survival and cell death. It will also be useful as a means of diagnosis, prevention and treatment development for diseases associated with apoptosis, such as cancer, autoimmune diseases, AIDS, neurodegenerative diseases such as Alzheimer's disease, and the like.

[0009] Upon further research, the present inventors have made additional discoveries. Specifically, it was found that DNasey expression is significantly lower in cancer lesion sites, and that almost no DNasey expression is seen in cancer cells such that apoptosis rarely occurs, but that introduction of the DNasey gene restores apoptosis ability. Furthermore, attention was focused on the fact that creation of antibodies for DNasey are useful since they can be utilized for diagnosis of the malignancy and prognosis for cancer. Attention was also directed to the fact that antibodies for DNasey are useful because they can also be utilized for analysis, diagnosis and treatment of apoptosis-related diseases including cancer, AIDS, autoimmune diseases and neurodegenerative diseases such as Alzheimer's disease.

## SUMMARY OF INVENTION

[0010] Highly specific antibodies provide a highly useful means for such analysis. By using highly specific antibodies it is possible to detect DNasey specifically and with high sensitivity, and measurement of DNasey can provide information useful for analysis and diagnosis of apoptosis-related conditions. It can also be used for purification of DNasey.

[0011] However, to date it has been difficult to obtain antibodies that are highly specific for DNasey. The present inventors have succeeded in fulfilling one of the conditions for obtaining such antibodies by isolating DNasey and elucidating the gene sequence and amino acid sequence thereof, thus making way for methods of producing antigen to be used for immunization. Generally speaking, if an antigen can be obtained with a certain degree of purity, it is possible to produce antibodies against it. However, production of antibodies is often difficult due to the properties of the antigen. With such antigens, it is necessary to study the conditions for obtaining such antibodies in light of general findings hitherto discovered, with additional research and trial-and-error on each of the antigens in order to obtain useful antibodies with high specificity and affinity.

[0012] It is therefore an object of the present invention to provide a method for production of antibodies that specifically recognize DNasey, as well as antibodies that specifically recognize DNasey and are useful for biochemical analysis and treatment and diagnosis of various diseases.

[0013] The present inventors have discovered a method for production of DNasey-specific antibodies by preparing different DNasey antigens and immunization and analysis. More precisely, it was found that it is difficult to produce specific antibodies by immunization with common recombinant proteins, and that antibodies for three different DNasey partial peptides do not recognize DNasey protein. However, it was found that it is possible to obtain DNasey protein-specific antibodies by using as the immunogen, a peptide corresponding to the C-terminal portion of DNasey.

[0014] In order to prepare specific antibodies for DNasey, the present inventors attempted to use various recombinant DNasey proteins and synthetic peptides as immunogens, based on the amino acid sequence for DNasey. It was found that when immunization is performed with DNasey protein, it is difficult to produce DNasey-specific antibodies since the antibody titer for DNasey does not increase sufficiently, and that using the three peptides other than the C-terminal portion as the immunogen yields antibodies that do not recognize the DNasey protein. As a result of diligent research it has been discovered that DNasey antibodies can be obtained by a useful method employing the C-terminal portion peptide of DNasey as the immunogen.

[0015] The present invention therefore provides antibodies that specifically recognizes DNasey protein. More particularly, it provides antibodies that specifically recognize peptides including the C-terminal amino acid sequence of DNasey protein. Even more particularly, it provides antibodies that specifically recognize peptides including the 12 amino acids: Val-Thr-Leu-Arg-Lys-Lys-Thr-Lys-Ser-Lys-Arg-Ser (SEQ ID No.1) of the C-terminus of human DNasey protein.

[0016] As concrete examples there may be mentioned monoclonal antibody hg302 produced by hybridoma hg302 (FERM P-17471) and monoclonal antibody hg303 produced by hybridoma hg303 (FERM P-17472).

[0017] The invention still further provides hybridomas that produce any of the antibodies described above. As concrete examples of such hybridomas there may be mentioned hybridoma hg302 (FERM P-17471) and hybridoma hg303 (FERM P-17472). The hybridoma hg302 was deposited at the National Institute of Bioscience and Human-Technology, 1-3, Higashi 1-chome Tsukuba-shi Ibaraki-ken 305-8566, Japan as FERM P-17471 on July 16, 1999 and transferred to an international deposition under the Budapest Treaty as FERM BP-7317 on October 12, 2000.

[0018] The hybridoma hg303 was deposited at the National Institute of Bioscience and Human-Technology, 1-3, Higashi 1-chome Tsukuba-shi Ibaraki-ken 305-8566, Japan as FERM P-17472 on July 16, 1999 and transferred to an international deposition under the Budapest Treaty as FERM BP-7318 on October 12, 2000.

[0019] The invention still further provides a method for production of any hybridoma, such as that described above, which is characterized by cloning cells obtained by fusion of spleen cells of a mammal immunized with a peptide containing a 5-20 amino acid sequence of the C-terminal portion of DNasey protein and myeloma cells of the same species. As a concrete example of such a sequence there may be mentioned the following amino acid sequence: Cys-Val-Thr-Leu-Arg-Lys-Lys-Thr-Lys-Ser-Lys-Arg-Ser (SEQ ID No.2).

[0020] The invention still further provides a method for immunological detection and measurement of DNasey, that comprises contacting an anti-DNasey antibody such as described above with a sample derived from a human or an animal believed to contain DNasey.

[0021] The invention still further provides a diagnostic reagent for prognosis of apoptosis-related conditions including cancer, AIDS, autoimmune diseases and neurodegenerative diseases such as Alzheimer's disease, which comprises an antibody such as described above.

[0022] The invention still further provides a method for purification of DNasey, which comprises contacting a solution containing DNasey with an affinity carrier prepared by binding an antibody such as described above to a high molecular carrier, for specific binding thereto, and then eluting the DNasey.

## BRIEF DESCRIPTION OF THE DRAWINGS

[0023]

5 The upper panel in Fig. 1 is a Western blot image showing the reactivity between the monoclonal antibodies of the invention and DNasey of different species, and the lower panel is a photographic image showing the results of electrophoresis (zymography) for the enzyme activity of each DNasey (Example 2(2)).

10 Lane 1 Negative control  
 Lane 2 Recombinant human DNasey  
 Lane 3 Recombinant human DNasey-Myc-His<sub>6</sub>-tagged fusion  
 Lane 4 Recombinant mouse DNasey-Myc-His<sub>6</sub>-tagged fusion  
 Lane 5 Recombinant rat DNasey-Myc-His<sub>6</sub>-tagged fusion

15 Fig. 2 is a Western blot image from electrophoresis showing the reactivity between the monoclonal antibodies of the invention and different human-derived DNase proteins (Example 2(2)), with the results shown as a photographic image.

20 Lane 1 Negative control  
 Lane 2 Recombinant human DNasey-Myc-His<sub>6</sub>-tagged fusion  
 Lane 3 Recombinant human DNase I-Myc-His<sub>6</sub>-tagged fusion  
 Lane 4 Recombinant human DNase X-Myc-His<sub>6</sub>-tagged fusion  
 Lane 5 Recombinant human DNAS1L2-Myc-His<sub>6</sub>-tagged fusion

25 Fig. 3 is an electrophoresis image (zymography) showing the results for immunoprecipitation of recombinant human DNasey using monoclonal antibodies hg303 of the invention or anti-Myc antibody, with the DNase activity shown as a photographic image.

30 Lane 1: Precipitate of recombinant human DNasey-Myc-His<sub>6</sub> by immunoprecipitation using antibody hg303  
 Lane 2: Supernatant of recombinant human DNasey-Myc-His<sub>6</sub> by immunoprecipitation using antibody hg303  
 Lane 3: Precipitate of recombinant human DNasey-Myc-His<sub>6</sub> by immunoprecipitation using anti-Myc antibody  
 Lane 4: Supernatant of recombinant human DNasey-Myc-His<sub>6</sub> by immunoprecipitation using anti-Myc antibody  
 Lane 5: Precipitate of recombinant human DNasey by immunoprecipitation using antibody hg303  
 Lane 6: Supernatant of recombinant human DNasey by immunoprecipitation using antibody hg303  
 35 Lane 7: Precipitate of recombinant human DNasey by immunoprecipitation using antibody anti-Myc antibody  
 Lane 8: Supernatant of recombinant human DNasey by immunoprecipitation using anti-Myc antibody

Fig. 4 shows a comparison between human, rat and mouse DNasey amino acid sequences (SEQ ID Nos. 3, 4, 5).

## 40 EMBODIMENT OF CARRYING OUT THE INVENTION

[0024] An anti-DNasey antibody according to the invention is characterized by being an anti-DNasey antibody that specifically recognizes a peptide including the amino acid sequence of the C-terminal portion of the DNasey molecule. The anti-DNasey antibodies of the invention are characterized by being able to specifically recognize DNasey protein.

45 [0025] The amino acid sequence of the C-terminal portion of the DNasey molecule differs between species (Fig. 4: SEQ ID Nos. 3, 4 and 5), and therefore preparation of antibodies for this portion can yield antibodies with high species specificity. That is, by using the amino acid sequence of the C-terminal portion of human DNasey for immunization it is possible to obtain antibodies specific for human DNasey, and by using the amino acid sequence of the C-terminal portion of rat DNasey for immunization it is possible to obtain antibodies specific for rat DNasey. The method of the invention relates not only to anti-human DNasey antibodies but can also be applied to production of antibodies for DNasey of other animal species.

[0026] A peptide containing the amino acid sequence of the C-terminal portion of the DNasey molecule is defined as a peptide containing a sequence of at least 5 amino acids including the C-terminal of the DNasey molecule, and it also includes fused peptides with other peptides and proteins. It also includes these peptides bound to carrier proteins such as bovine serum albumin (BSA) and ovalbumin (OVA) for enhanced immunogenicity. The hybridomas of the invention are hybridomas having the ability to produce monoclonal antibodies that can specifically recognize the C-terminal sequence of DNasey and can specifically recognize DNasey protein.

55 [0027] The aforementioned peptide comprising at least 5 amino acid residues and preferably 5-20 amino acid res-



idues may be used as an immunogen to obtain antibodies. It is common to employ a method in which the peptide is chemically bound to a carrier protein such as KLH, BSA or OVA for increased immunogenicity. For the chemical bonding, peptides including cysteine at the binding sites may be constructed and the -SH group of cysteine used for binding with the carrier protein. When a peptide of the C-terminal portion is used, it is common to bind the carrier protein at a cysteine at the N-terminal of the peptide.

[0028] Any of various chemical crosslinking agents may be used for the chemical binding of the peptide and carrier protein. A crosslinking agent with appropriate reactivity with the target functional group is selected. For example, for crosslinking between an amino group and -SH group, succinimidyl-4-[N-maleimidomethyl]cyclohexane-1-carboxylate (SMCC) or N-succinimidyl-3-[2-pyridyldithio]propionate (SPDP) or the like is used.

[0029] Guinea pigs, rats, mice or the like may be used to obtain the monoclonal antibodies, but mice are preferred for simplicity of production and procedure. The immunization method may be by any route such as intraabdominally, subcutaneously, intravenously, intramuscularly or intradermally for immunization of a mouse, for example, but intraabdominal, subcutaneous or intravenous injection are primarily preferred. Numerous methods with high variability in terms of immunization interval and immunization dose are possible, but common methods use spleen cells extracted 1-5 days and preferably about 2-4 days after final immunization of about 2-6 immunizations at 2-week intervals, for example.

[0030] The immunization dose is about 0.1  $\mu$ g or greater and preferably about 1-30  $\mu$ g per mouse, as the single peptide amount. Before extraction of the spleens, it is preferred to conduct a fusion experiment using the spleen cells after partial blood collection to confirm blood antibody titer increase. Cell fusion between the spleen cells and lymphoid cells is accomplished by fusing the extracted mouse spleen cells with an appropriate lymphoid cell line such as myeloma (e.g., SP2, P3-X63-Ag  $\cdot$  8UI) from the same species or a different species (preferably the same species) using a hypoxanthine-guanine-phosphorybosyl transferase negative (HGPRT) or thymidine kinase negative (TK<sup>-</sup>) marker.

[0031] These may be produced by fusion according to the lane method, for example (Methods in Enzymology, 121, 1980; 183-192). That is, myeloma cells and spleen cells, for example, are suspended at a proportion of about 3:5 in RPMI 1640 medium, for example, and a fusing agent such as polyethylene glycol (PEG) or Sendai virus is used. The polymerization degree of the PEG is normally about 1000-6000, the time is about 0.5-30 minutes and the concentration is 10-80%; however, efficient fusion can be achieved by treatment using PEG 1500 at about 35% for about 4-10 minutes, as a preferred example of conditions.

[0032] The cell fusion may be carried out by selective and efficient growth using hypoxanthine-azaserine medium (HA medium). The cell culture supernatant resulting from the growth may be screened to determine whether the target antibodies have been produced, and the antibody titer screening may be carried out in the following manner. That is, the presence of production of antibodies against the immunized peptide may be examined by a method such as Enzyme ImmunoAssay (EIA) or Radio ImmunoAssay (RIA), and various modifications are possible within these methods.

[0033] One method based on EIA will be examined as a preferred assay method. An immunized peptide is coated onto a 96-well microtest plate by a common method, and the culture supernatant or mouse serum to be measured is added and reacted therewith for a fixed time at a constant temperature (approximately 4-40°C, same hereunder). After then thoroughly washing the reaction product, enzyme-labeled anti-mouse immunoglobulin antibody, for example, (obtained by coupling of the enzyme and antibody by a common method followed by purification) is added for reaction for a fixed time at a constant temperature. After thoroughly washing the reaction product, the enzyme substrate is added for reaction for a fixed time at a constant temperature, and then the color produced is measured by absorbance or fluorescence.

[0034] The cells in the wells in which growth in the selective medium was observed and antibody activity was detected for the peptide used for immunization, are preferably cloned by the limiting dilution method or a similar method. The supernatant of the cloned cells is screened in the same manner and the cells in the wells with high antibody activity are increased to obtain monoclonal antibody-producing hybridoma clones exhibiting reactivity with the immunized peptide. The hybridomas cloned in this manner may be grown in liquid medium to obtain the monoclonal antibodies from the culture solution.

[0035] The antibodies can also be obtained by intraabdominally inoculating a mammalian animal, allowing the cells to proliferate and collecting the ascitic fluid. For this purpose, in the case of mice for example, BALB/c mice previously inoculated with pristane (tetramethylpentadecane), mineral oil or the like are then intraabdominally inoculated with approximately  $1 \times 10^4$  -  $1 \times 10^7$ , and preferably approximately  $5 \times 10^5$  -  $2 \times 10^6$  hybridoma cells, and after about 7-20 days and preferably about 10-14 days, the ascitic fluid is collected. The antibodies accumulated in the ascitic fluid can be obtained by easily isolating the monoclonal antibodies as pure immunoglobulins by, for example, ammonium sulfate precipitation, protein A affinity chromatography, or the like.

[0036] The method for immunological detection of DNasey according to the invention is characterized by contacting the monoclonal antibodies with a sample containing tissue, body fluid or a cell line from a human or animal believed to contain DNasey, to detect the DNasey.

[0037] Immunochemical detection methods that may be applied for the invention include, for example, immunohis-

tostaining, Western blotting, agglutination reaction, agglutination inhibition, immunodiffusion, immunonephelometry, latex nephelometry, competitive assay (solid phase method, second antibody method), sandwich assay, immunometric assay, liposome immunolysis assay (LILA) or the like, and detection methods using labeling substances include radio-immunoassay (RIA), enzyme immunoassay (EIA), fluorescent immunoassay (FIA), chemiluminescent immunoassay, metal immunoassay, spin immunoassay and the like.

[0038] The present invention provides a method for production of specific antibodies for DNasey. According to the invention, immunization is carried out with an amino acid sequence specific for DNasey protein, and therefore DNasey-specific antibodies are obtained that do not cross-react with other DNase proteins such as DNaseI and DNaseX. Also, because the amino acid sequence of the C-terminal portion of DNasey is less conserved among animal species (Fig. 4), antibodies for this portion have high species specificity. In other words, anti-human DNasey antibodies of the invention do not cross-react with DNasey of other species. The anti-DNasey antibody production method of the invention is not limited to animal species. It may be applied to production of antibodies for human DNasey as well as for DNasey of other species.

[0039] The antibodies of the invention allow specific and convenient detection of DNasey protein, and therefore provide a means of analyzing the function and pathological significance of DNasey protein in the field of medical biology. In addition, since DNasey protein is a DNase associated with apoptosis and DNasey expression decreases with canceration or malignant degeneration, the antibodies of the invention can be used in the medical and pharmaceutical industry as agents for research, diagnosis and treatment of apoptosis-related conditions including cancer, AIDS, autoimmune diseases and neurodegenerative diseases such as Alzheimer's disease. The antibodies of the invention are also useful for analysis of conditions using animal models for apoptosis-related diseases. This is expected to be of use in predicting and detecting apoptosis sensitivity and particularly to be of use in the analysis, treatment and diagnosis of conditions related to apoptosis.

## EXAMPLES

[0040] The present invention will now be explained in more detail by way of examples and reference examples which, however, are in no way intended to restrict the invention.

### Example 1. Production of monoclonal antibodies

#### Preparation of human DNasey peptide antigen

[0041] Peptide hg3 (Cys-Val-Thr-Leu-Arg-Lys-Lys-Thr-Lys-Ser-Lys-Arg-Ser) (SEQ ID No.2) comprising 13 amino acids including a 12 amino acid sequence corresponding to the C-terminal portion of human DNasey, was chemically synthesized by the Fmoc method and was subjected to salting out and purification.

[0042] Bovine serum albumin (BSA) and ovalbumin (OVA) were dissolved in a 0.1 M phosphate buffer solution (pH 7.0) as carrier proteins, 50 molar equivalents of SMCC (Pierce Co.) were added and reacted with the amino groups of the carrier proteins for introduction of NHS groups, and the unreacted components were removed by gel filtration. The peptide hg3 was dissolved in 0.5 mM EDTA and 0.1 M phosphate buffer solution (pH 6.0) and 50 molar equivalents of peptide was mixed with the carrier protein into which NHS groups had been introduced, for reaction with the SH groups of the peptide. The unreacted components were removed by dialysis to yield hg3-BSA, hg3-OVA conjugates.

#### Preparation of hybridomas

##### (1) Immunization

[0043] The hg3-BSA was administered through the abdomen of BALB/c mice with Freund's complete adjuvant (FCA), at 20 µg per mouse. After 2, 4, 7 and 9 weeks, a booster immunization of 5-10 µg of hg3-BSA was administered through the abdomen of the mice with Freund's incomplete adjuvant (FIA).

##### (2) Cell fusion

[0044] A 5 µg portion of hg3-BSA was intravenously administered to the immunized mice, and after 3 days from administration the spleens were extracted and the spleen cells obtained. A common method was applied for cell fusion of the spleen cells with the mouse myeloma cell line SP2/0 Ag14 using polyethylene glycol, and then HAT medium was used for selective growth of the hybrid cells.

(3) Screening and cloning of antibody-producing cells

[0045] hg3-OVA was first immobilized on a 96-well polystyrene microtest plate, the culture supernatant of the hybrid cells was reacted therewith, and primary screening was performed for anti-human DNasey antibody-producing cells by solid phase enzyme-linked immunoassay (ELISA) using HRP-labeled goat anti-mouse IgG antibody (Jackson Immune Research). A secondary screening was then performed by ELISA in the same manner using a plate with recombinant human DNasey in solid phase.

[0046] Next, the human DNasey protein-specific antibody-producing wells were selected and the cells were cloned by the limiting dilution method. As a result, two different hybridomas were obtained and were designated as hybridoma hg302 and hg303, respectively.

[0047] The hybridomas hg302 and hg303 have been deposited at the National Institute of Bioscience and Human Technology on July 16, 1999 as FERM P-17471 and FERM P-17472, respectively.

Purification and immunoglobulin classification of monoclonal antibodies

[0048] The mouse hybridoma cells producing monoclonal antibodies specific for human DNasey protein were intraabdominally inoculated into mature BALB/c mice that had already been intraabdominally administered pristane (tetramethylpentadecane), and after 10-14 days the abdomens of the mice that had enlarged due to proliferation of the hybridomas were dissected and the ascites fluid was collected. The antibodies were purified from the collected ascitic fluid using a HiTrap Protein A Column (Pharmacia).

[0049] The immunoglobulin class of the purified antibodies was determined using a mouse monoclonal antibody subclass ID kit (Zymed). As a result, the anti-human DNasey protein monoclonal antibodies hg302 and hg303 were both found to be IgG1,  $\kappa$ .

Example 2. Property analysis of monoclonal antibodies

[0050] The specificity and reactivity of the antibodies of the invention are extremely high, and they can therefore be used for Western blotting, immunoprecipitation, immunostaining and the like, as well as for analysis of DNA cleaving and apoptosis, which are the functions of human DNasey protein. Examples are given below. Figs. 1-3 show the results of using hg303 monoclonal antibody for illustration, but similar results are obtained with hg302 monoclonal antibody as well.

(1) Preparation of antigen protein-expressing cells to be used for analysis.

[0051] The following primer pair was used for amplification of an open reading frame of DNasey containing the termination codon by PCR from cDNA constructed using spleen-derived polyA(+)RNA as the template, and this was followed by subcloning in pBluescript II KS+.

DNasey sense primer: GCTAGCCACCATGTCACGGGAGCTGGCC (SEQ ID No:6)

DNasey antisense primer 1: GCTAGCCTAGGAGCGTTTGCTCTTTG (SEQ ID No:7) (with linker sequence containing NheI recognition site (GCTAGC) added to 5' end)

[0052] After confirming the sequences by cycle sequencing, the DNasey in-site DNA cut out by NheI digestion was subcloned at the XbaI site of pcDNA3.1-Myc-His B (Invitrogen Co.), to obtain the wild type DNasey-coding expression vector phDNasey.

[0053] The following primer pair was used for amplification of the open reading frames of human DNasey, DNase I, DNase X and DNAS1L2 minus the termination codon by PCR from cDNA constructed using spleen-derived, placenta-derived, GOTO cell-derived and HeLa cell-derived polyA(+)RNA as the template, respectively, and this was followed by subcloning in pBluescript II KS+.

DNasey sense primer: GCTAGCCACCATGTCACGGGAGCTGGCC (SEQ ID No:6)

DNasey antisense primer 2: GCTAGCGAGCGTTTGCTCTTTG (SEQ ID No:8) (with linker sequence containing NheI recognition site (GCTAGC) added to 5' end)

DNase I sense primer: CTCGAGCCACCATGAGGGGCATGAAGCTGCTG (SEQ ID No:9)

DNase I antisense primer: CTCGAGACTTCAGCATCACCTCCACTG (SEQ ID No:10)

DNase X sense primer: CTCGAGCCACCATGCACTACCCAAGTGCAC (SEQ ID No:11)

DNase X antisense primer: CTCGAGAGGCAGCAGGGCACAGCTGA (SEQ ID No:12)

DNAS1L2 sense primer: CTCGAGCCACCATGGGCGGGCCCCGGGCT (SEQ ID No:13)

DNAS1L2 antisense primer: CTCGAGATCGGTGGAAGTTGAGGGTAC (SEQ ID No:14) (with linker sequence containing XhoI recognition site (CTCGAG) added to each at 5' end)

5 [0054] After confirming the sequences by cycle sequencing, the DNasey in-site DNA cut out by NheI digestion was subcloned at the XbaI site of pcDNA3.1-Myc-His B (Invitrogen Co.), to obtain the DNasey-coding expression vector phDNasey-Myc-His, containing Myc and histidine tags at the C-terminus. The in-site DNA cut out by XhoI digestion was recloned at the XhoI site of pcDNA3.1-Myc-His C (Invitrogen Co.), to obtain the DNase I-, DNase X- and DNAS1L2-coding expression vectors phDNase I-Myc-His, phDNase X-Myc-His, phDNAS1L2-Myc-His, containing Myc and histidine tags at the C-terminals.

10 [0055] These expression vectors were each used for transfection of  $1 \times 10^6$  HeLa S3 cells, and after 39 hours of culturing, cells were collected which expressed human DNasey and human, mouse and rat DNasey-Myc-His<sub>6</sub>-tagged fusion proteins, and the protein analogues human DNase I-Myc-His<sub>6</sub>, DNase X-Myc-His<sub>6</sub> and DNAS1L2-Myc-His<sub>6</sub>.

## (2) Reactivity of DNasey of each animal species by Western blotting

15 [0056] The cells expressing the human DNasey- and human, mouse and rat DNasey-Myc-His<sub>6</sub>-tagged fusion proteins were subjected to SDS-polyacrylamide gel electrophoresis (SDS-PAGE) at  $2 \times 10^5$  cells/lane. The protein in the gel was transferred to a nitrocellulose membrane, and the membrane was subjected to blocking with 2.5% dry milk and then reacted for one hour at room temperature with the anti-human DNasey monoclonal antibodies hg302 and hg303.  
20 After rinsing, it was further reacted for one hour at room temperature with alkaline phosphatase-labeled anti-mouse IgG (NEW ENGLAND BioLabs) and rinsed, and then the coloration was detected using BCIP/NBT as the substrate.

[0057] The upper panel in Fig. 1 shows the reaction of anti-DNasey monoclonal antibody hg303.

Lane 1 Negative control

25 Lane 2 Recombinant human DNasey

Lane 3 Recombinant human DNasey-MycHis<sub>6</sub>-tagged fusion

Lane 4 Recombinant mouse DNasey-MycHis<sub>6</sub>-tagged fusion

Lane 5 Recombinant rat DNasey-MycHis<sub>6</sub>-tagged fusion

30 [0058] This demonstrates that the antibodies of the invention react specifically with human DNasey protein of molecular weight 33 kDa and with the human DNasey-Myc-His<sub>6</sub> fusion protein of 36 kDa, but do not cross-react with mouse and rat DNasey. That is, high species specificity was exhibited by the antibodies of the invention.

[0059]  $1 \times 10^5$  cells/lane of each of the protein-expressing cells were subjected to SDS-PAGE with dsDNA containing gel. The gel was rinsed for one hour at 50°C in a solution containing 5 mM 2-mercaptoethanol (2-ME) and 10 mM  
35 Tris-HCl (pH 7.8), and then the protein in the gel was subjected to refolding at 4°C for 3 hours in a solution containing 10 mM Tris-HCl (pH 7.8). The gel was transferred into a solution containing 1 mM 2-ME, 3 mM CaCl<sub>2</sub>, 3 mM MgCl<sub>2</sub> and 10 mM Tris-HCl (pH 7.8), for degradation reaction of the dsDNA with DNase at 37°C for 10 hours. Fluorescent staining was performed with ethidium bromide, and the remaining dsDNA was detected. The portions of dsDNA degradation by the DNase appear black.

40 [0060] The results are shown in the lower panel of Fig. 1. Roughly the same enzyme activity is seen in lanes 2-5, indicating approximately the same amounts of DNase protein.

## (3) Reactivity with DNasey analog proteins by Western blotting

45 [0061] The cells expressing the human DNasey-Myc-His<sub>6</sub>-, DNase I-Myc-His<sub>6</sub>-, DNase X-Myc-His<sub>6</sub>- and DNAS1L2-Myc-His<sub>6</sub>-tagged fusion proteins were subjected to SDS-PAGE at  $2 \times 10^5$  cells/lane. The protein in the gel was transferred to a nitrocellulose membrane, and the membrane was subjected to blocking with 2.5% dry milk and then reacted for one hour at room temperature with the anti-human DNasey monoclonal antibodies hg302 and hg303. After rinsing, it was further reacted for one hour at room temperature with alkaline phosphatase-labeled anti-mouse IgG  
50 (NEW ENGLAND BioLabs) and rinsed, and then the coloration was detected using BCIP/NBT as the substrate.

[0062] The results with hg303 monoclonal antibody are shown in Fig. 2.

Lane 1 Negative control

Lane 2 Recombinant human DNasey-Myc-His<sub>6</sub>-tagged fusion

55 Lane 3 Recombinant human DNase I-Myc-His<sub>6</sub>-tagged fusion

Lane 4 Recombinant human DNase X-Myc-His<sub>6</sub>-tagged fusion

Lane 5 Recombinant human DNAS1L2-Myc-His<sub>6</sub>-tagged fusion



[0063] Fig. 2 shows that the antibodies of the invention react specifically with the human DNasey-Myc-His<sub>6</sub> fusion protein of molecular weight 36 kDa, but do not cross-react with the analog proteins DNase I, DNase X and DNASIL2 that are homologous with DNasey.

5 (4) Reactivity by immunoprecipitation

[0064] Cells expressing human DNasey and human DNasey-Myc-His<sub>6</sub>-tagged fusion proteins were dissolved in 0.3% NP-40 solution at  $1 \times 10^5$  cells, and then the anti-human DNasey monoclonal antibodies hg302, hg303 or anti-Myc antibody (Invitrogen) were added to the supernatant after centrifugal separation, for reaction at 4°C for 90 minutes.  
10 Protein G Sepharose FF was added at 1/10 the volume of the cell extract and then further reaction for 60 minutes was followed by centrifugation to obtain a supernatant (S). The precipitate was rinsed 3 times with NP-40 solution and dissolved in an SDS-PAGE sample buffer, to obtain a precipitate (P). Both S and P were applied to a gel containing dsDNA at approximately  $1 \times 10^5$  cells/lane, and after SDS-PAGE the DNA degrading activity was analyzed in the same manner as above.

15 [0065] Fig. 3 shows the results of immunoprecipitation with hg303 monoclonal antibody.

Lane 1: Precipitate of recombinant human DNasey-Myc-His<sub>6</sub> by immunoprecipitation using antibody hg303  
Lane 2: Supernatant of recombinant human DNasey-Myc-His<sub>6</sub> by immunoprecipitation using antibody hg303  
Lane 3: Precipitate of recombinant human DNasey-Myc-His<sub>6</sub> by immunoprecipitation using anti-Myc antibody  
20 Lane 4: Supernatant of recombinant human DNasey-Myc-His<sub>6</sub> by immunoprecipitation using anti-Myc antibody  
Lane 5: Precipitate of recombinant human DNasey by immunoprecipitation using antibody hg303  
Lane 6: Supernatant of recombinant human DNasey by immunoprecipitation using antibody hg303  
Lane 7: Precipitate of recombinant human DNasey by immunoprecipitation using antibody anti-Myc antibody  
Lane 8: Supernatant of recombinant human DNasey by immunoprecipitation using anti-Myc antibody

25 [0066] Fig. 3 shows that human DNasey precipitates with anti-human DNasey hg303 antibody but not with anti-Myc antibody, while human the DNasey-Myc-His<sub>6</sub>-tagged fusion protein precipitates with anti-human DNasey hg303 antibody and anti-Myc antibody.

[0067] The results indicated that the anti-human DNasey hg303 antibody also reacts with human DNasey under  
30 solution conditions.

Reference Example 1. Preparation of recombinant human DNasey

[0068] Human DNasey cDNA was incorporated into a thioredoxin (Trx)-histidine-tagged fusion protein expression vector (pET32a, Novagene) and a glutathione S transferase (GST) fusion protein expression vector (pGEX3X, Pharmacia), and then Trx-DNasey was expressed in *E. coli* strain AD494(DE3) and GST-DNasey was expressed in strain DH5α. The *E. coli* were cultured and the cells were collected by centrifugation. The collected cells were lysed and then the respective recombinant proteins were purified by affinity chromatography using a cobalt-binding column and a glutathione-binding column.

40 Reference Example 2. Immunization with recombinant human DNasey

[0069] A 20 μg portion of the aforementioned Trx-DNasey and GST-DNasey was intraabdominally administered to BALB/c mice with FCA. At 2 and 4 weeks after administration, 5-10 μg was intraabdominally administered as a booster  
45 with FIA to the mice. One week after the final immunization, when blood was sampled from the tail and the antibody titer thereof measured by antigen solid phase ELISA, the antibody titer for Trx and GST were both higher but no increase was found in the antibody titer for DNasey. It was thus demonstrated that production of anti-DNasey antibodies is difficult by immunization of common recombinant proteins.

50 Reference Example 3. Synthesis of hg1, hg2 #1740 and immunization

[0070] The Fmoc method was used for chemical synthesis followed by salting out and purification of peptide hg1 (SEQ ID No. 15) comprising 12 amino acids including an 11 amino acid sequence corresponding to human DNasey (76-86), peptide hg2 (SEQ ID No. 16) comprising 11 amino acids including a 10 amino acid sequence corresponding to  
55 human DNasey (139-148) and peptide #1740 (SEQ ID No. 17) comprising 10 amino acids including a 9 amino acid sequence corresponding to human DNasey (79-87).

[0071] Bovine serum albumin (BSA) and ovalbumin (OVA) were reacted with SMCC (Pierce) to introduce NHS groups. After removing the unreacted components, the SH groups of the aforementioned peptides hg1, hg2 and #1740

were reacted therewith to construct the conjugates hg1-BSA, hg1-OVA, hg2-BSA, hg2-OVA, #1740-BSA and #1740-OVA. A 20 µg portion each of hg1-BSA, hg2-BSA and #1740-BSA was intraabdominally administered with FCA to BALB/c mice.

[0072] After 2 and 4 weeks, 10 µg each of hg1-BSA, hg2-BSA and #1740-BSA was intraabdominally given to the mice with Freund's incomplete adjuvant (FIA) as a booster immunization. One week after the final immunization, blood was sampled from the tail and the antibody titer thereof measured by antigen solid phase ELISA. The antibody titers for hg1-OVA, hg2-OVA and #1740-OVA, i.e. the antibody titers for the peptides, were higher but no increase was found in the antibody titer for DNasey protein. It was thus demonstrated that antibodies for peptides hg1, hg2 and #1740 cannot recognize DNasey protein.

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## SEQUENCE LISTING

<110> Advanced Life Science Institute, Inc.

5 <120> Anti-DNase gamma antibody, as well as production and  
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 50 55 60  
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 His Arg Trp Lys Ala Glu Asn Phe Ile Phe Met Gly Asp Phe Asn Ala  
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 245 250 255  
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 Val Arg Ser Phe Gly Glu Ser Lys Lys Glu Asn His Asn Ala Met Asp  
 35 40 45  
 Ile Ile Val Lys Ile Ile Lys Arg Cys Asp Leu Ile Leu Leu Met Glu  
 50 55 60  
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 65 70 75 80  
 Asn Gly Asn Ser Arg Arg Ser Thr Thr Tyr Asn Tyr Val Ile Ser Ser  
 85 90 95  
 Arg Leu Gly Arg Asn Thr Tyr Lys Glu Gln Tyr Ala Phe Leu Tyr Lys  
 100 105 110  
 Glu Lys Leu Val Ser Val Lys Ala Lys Tyr Leu Tyr His Asp Tyr Gln  
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1

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# Claims

1. An antibody that specifically recognizes DNasey protein.
2. An antibody according to claim 1 that specifically recognizes a peptide including the C-terminal amino acid sequence of DNasey protein.
3. An antibody according to claim 1 or 2 that specifically recognizes a peptide including the 12 amino acids: Val-Thr-Leu-Arg-Lys-Lys-Thr-Lys-Ser-Lys-Arg-Ser (SEQ ID No.1) of the C-terminus of human DNasey protein.
4. An antibody according to any one of claims 1 to 3, which is monoclonal antibody hg302 produced by hybridoma hg302 (FERM P-17471) or monoclonal antibody hg303 produced by hybridoma hg303 (FERM P-17472).
5. A hybridoma that produces an antibody according to any one of claims 1 to 4.
6. A hybridoma according to claim 5, which is hybridoma hg302 (FERM P-17471) or hybridoma hg303 (FERM P-17472).
7. A method for production of a hybridoma according to claim 5, characterized by cloning cells obtained by fusion of spleen cells of a mammal immunized with a peptide containing a 5-20 amino acid sequence of the C-terminal portion of DNasey protein and myeloma cells of the same species.

8. The method of claim 7, wherein said amino acid sequence of the C-terminal portion is the following sequence: Cys-Val-Thr-Leu-Arg-Lys-Lys-Thr-Lys-Ser-Lys-Arg-Ser (SEQ ID No.2).

5 9. A method for immunological detection and measurement of DNasey, that comprises contacting anti-DNasey antibody according to any one of claims 1 to 4 with a sample derived from a human or animal believed to contain DNasey.

10 10. A diagnostic reagent for prognosis of apoptosis-related conditions including cancer, AIDS, autoimmune diseases and neurodegenerative diseases such as Alzheimer's disease, which comprises an antibody according to any one of claims 1 to 4.

15 11. A method for purification of DNasey, which comprises contacting a solution containing DNasey with an affinity carrier prepared by binding an antibody according to any one of claims 1 to 4 to a high molecular carrier, for specific binding thereto, and then eluting the DNasey.

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Fig.1

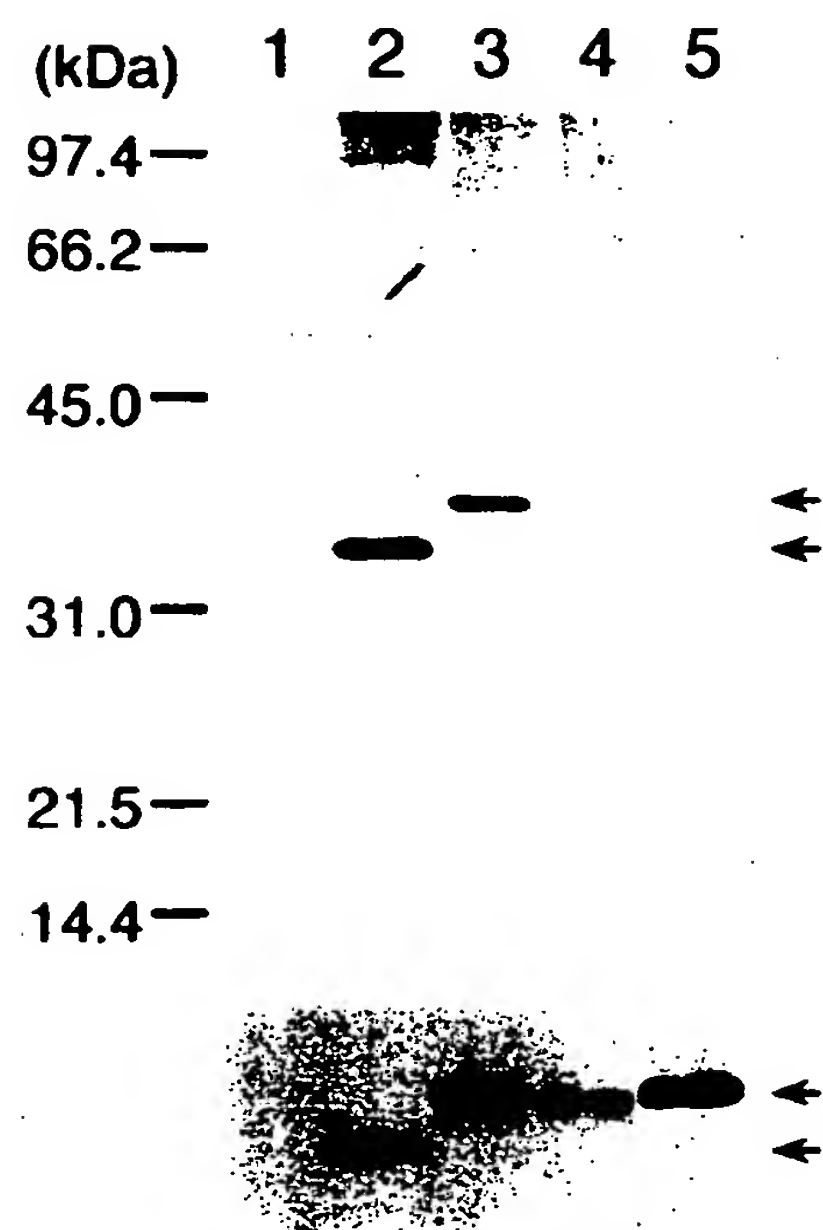




Fig.2

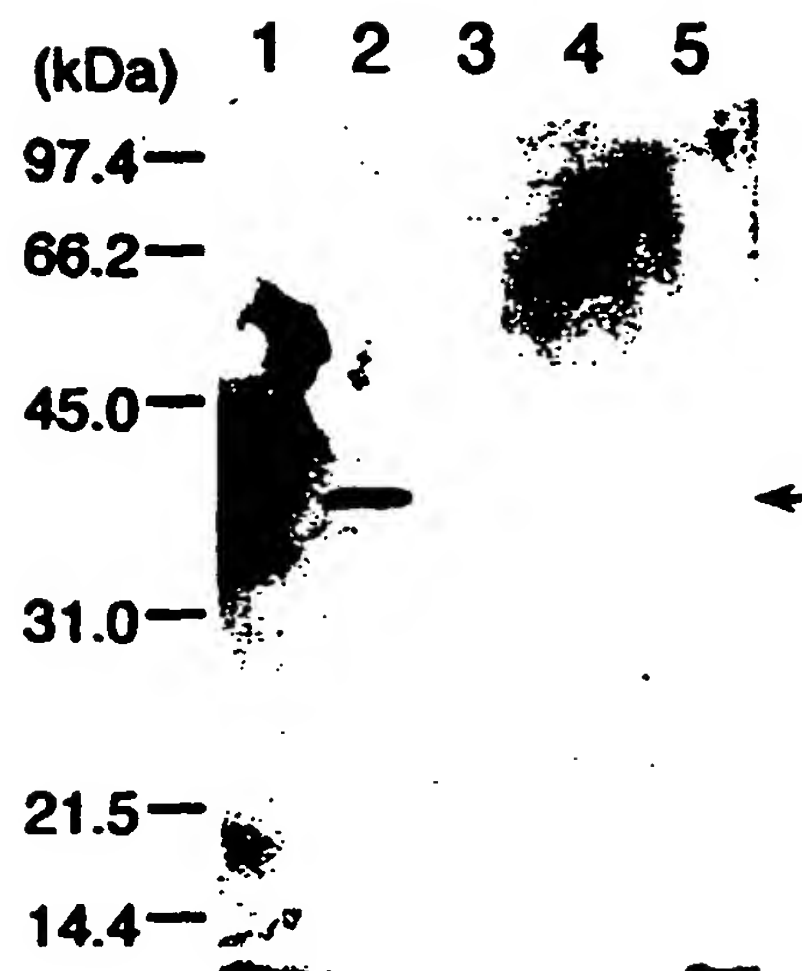
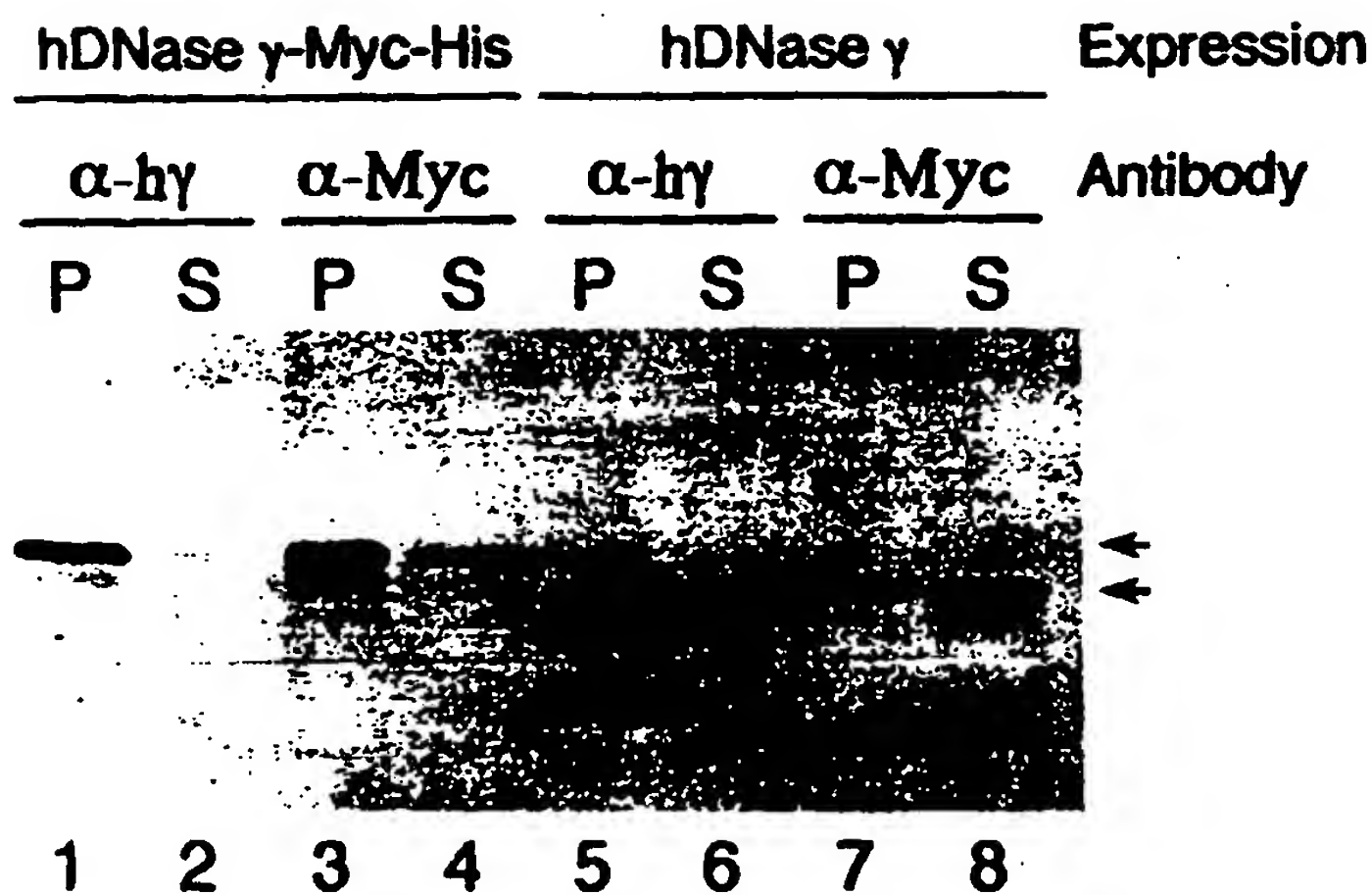


Fig.3



## Fig.4

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 MOUSE MSLHPASPRLASLLLFIHALHDTLALRLCSFNVRSPFGASKKENHEAMDII  
 \*\* \*\* .\*\*\*\*. .\*. .\*. .\*\*\*\*\* \*\*.\*. .\*\*\*\*.\*

HUMAN VKVIKRCDIILVMEIKDSNNRICPILMEKLNRRNSRRGITYNYVISSRLGR  
 RAT VKIIRCDLILLMEIKDSNNNICPMLMEKLNNGNSRRSTTYNYVISSRLGR  
 MOUSE VKIIRCDLILLMEIKDSSNNICPMLMEKLNNGNSRRSTTYNYVISSRLGR  
 \*\* .\*\*\*\*\*. \*\*.\*\*\*\*\*. \* \*\*\*.\*\*\*\*\* \*\*\*\*\*.\*\*\*\*\*.\*\*\*\*\*

HUMAN KTYKEQYAFLYKEKLVSVKRSYHYHDYQDGDADVFSREPFVWVFQSPHTA  
 RAT NTYKEQYAFLYKEKLVSVKAKYLYHDYQDGDADVFSREPFVWVFQAPFTA  
 MOUSE NTYKEQYAFVYKEKLVSVKTKYHYHDYQDGDADVFSREPFVWVFHSPFTA  
 .\*\*\*\*\*.\*\*\*\*\* \* \*\*\*\*\*.\*\*\*\*\*.\*\*\*\*\*..\* \*\*

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 RAT AKDFVIVPLHTTPETSVKEIDELADVYTDVRRRWKAENFIFMGDFNAGCS  
 MOUSE VKDFVIVPLHTTPETSVKEIDELVDVYTDVRSQWK TENFIFMGDFNAGCS  
 \*\*\*\*\*.\*\*\*\*\*.\*\*\*\*\*.\*\*\*\*\*.\*\*\*\*\*.\*\*\*\*\*.\*\*\*\*\*

HUMAN YVPPKAWKNIRLRTDPRFVWLIGDQEDTTVKKSTNCAYDRIVLRGQEIVS  
 RAT YVPPKAWKNIRLRTDPNFVWLIGDQEDTTVKKSTSCAYDRIVLRGQEIVN  
 MOUSE YVPPKAWQNIRLRTDPKFVWLIGDQEDTTVKKSTSCAYDRIVLCCQEIVN  
 \*\*\*\*\*.\*\*\*\*\* \*\*\*\*\*.\*\*\*\*\*.\*\*\*\*\* \*\*\*\*\*.

HUMAN SVVPKSNVDFDFQKAYKLTEEEALDVSDHFPVEFKLQSSRAFTNSKKSVT  
 RAT SVVPRSSGVDFDFQKAYELSEEEALDVSDHFPVEFKLQSSRAFTNSRKSVS  
 MOUSE SVVPRSSGVDFDFQKAYDLSEEEALDVSDHFPVEFKLQSSRAFTNNRKSVS  
 \*\*\*\*\*.\*.\*\*\*\*\* \* \*\*\*\*\*.\*\*\*\*\*.\*\*\*\*\*..\*\*\*\*.

HUMAN LRKKT KSKRS  
 RAT LKKKKKGSRS  
 MOUSE LKKRKKGNRS  
 \*.\*. \*.\*\*